A Comparison of Physicochemical Investigations on Surface Soils from Gold Mine, Processing Site and Nearby Paddy Field

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Abstract

This study revealed a comparison of physicochemical properties of soil from a well known gold deposit and its neighbouring area. The aim of this research is to provide anthropogenic background concentration of surface soils from Sinkgu Township, Mandalay Region, Myanmar. Multi-increment soil sampling technique was applied for getting representative sample of each site. To compare surface soil qualities, physical and chemical parameters, texture, available NPK, exchangeable cations and heavy metal concentrations were detected. Soil nutrient levels are low in gold mine and processing sites but cadmium(Cd), lead(Pb), zinc(Zn), chromium(Cr), iron(Fe) heavy metals were observed as higher amounts than nearby agricultural land. Although agricultural soil gave better response for fertility qualifications than gold production sites, it informed that contained considerable high amount of arsenic(As) and mercury(Hg).The resulting data will contribute to local people the hazard of toxic pollutant heavy metals and indicate the needed soil fertilities for the agriculture

Keywords : Physicochemical properties, texture ,available NPK, exchangeable cations, heavy metal

Introduction

The world consists of 71% water and 29% land. Of the 29%, 58% are dry, cold ice deserts; 87% of land with an approximately 1m deep layer of soil to feed, house and sustain all the people of the earth. Life on earth depends critically on the soil resource. Soil is not only an important medium for plant growth but also a treatment filter for maintaining water quality, a key component in the regulation of the global biogeochemical cycles and an important medium for the disposal and delegation of wastes. Despite the importance of these functions, we often treat soil with contempt, often referring to its as 'dirt' and describing things as 'soiled' when no longer saleable. While soils are essential to human society as air and water, soil degradation has not received nearly is much attention as the threats to these other two elements. Soil health is defined as "the capacity of a soil to function within ecosystem boundaries to sustain biological productivity, maintain environmental health, and promote plant and animal health." Soil properties that determine soil health include soil physical, chemical, and biological properties. In some cases, the term "soil

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quality" may be used; the two terms have the same meaning. It is commonly accepted today that the chemical and physical properties of soils determine their capacity to support plant growth. Throughout most of recorded history data concerning these properties have not been available for the soils commonly used for crop production, thus soil fertility practices have been based upon empirical knowledge. Agricultural soil analysis is a chemical analysis that is used assess the plant-availability of essential nutrients and toxic elements. Soils normally contain low background levels of heavy metal, but geogenic, biogenic and anthropogenic effects can cause the damage of ecosystems and redistribution of heavy metals to the environment through pollution of the air, water and soil. Natural background concentration is defined as the ambient concentrations of chemical in soils without human influence (Gough, 1993), which depicts an idealized situation (i.e pristine soil). Anthropogenic background concentration is defined as both natural and man-made substances present in the environment as a result of human activities not specifically related to point sources (Breckenridge and Crockett, 1995). Urban activities such as transportation, construction, cultivation and manufacturing have resulted in increased release of heavy metals. Among them, gold mining produces more contaminants than other activities because gold can always be occurred together with the toxic metals such as As, Pb, Hg and Cd etc. Anthropogenic activities, such as pesticide and herbicide application, metal mining and smelting, fossil fuel combustion, chemical production; wastes incineration and mercury amalgamation for gold mining and irrigation with contaminated groundwater have significantly enhanced arsenic and other heavy metal levels in agricultural soil in many parts of the world. Heavy metal contamination in soil is a major concern because of their toxicity and threat to human life and the environment. This research only focused on some physical and chemical aspects of surface soil quality from Tha yet chaung, Kyi tauk pauk and Nwe yon villages, Sinkgu township, Pyin oo lwin district, Mandalay region. By applying the research knowledge, gold producer, processing owner, mine-workers and farmers can be able to notice the qualities of their soils and manage the required protective arrangement and soil remediation.

Aim and Objectives

Aim

The aim of this research is to provide surface soil qualities of gold mine and its surrounding area.

Objectives

- To collect increment soil samples
- To prepare representative soil samples
- To analyze physicochemical properties of soil samples
- To provide recommendations based on interpreted research data

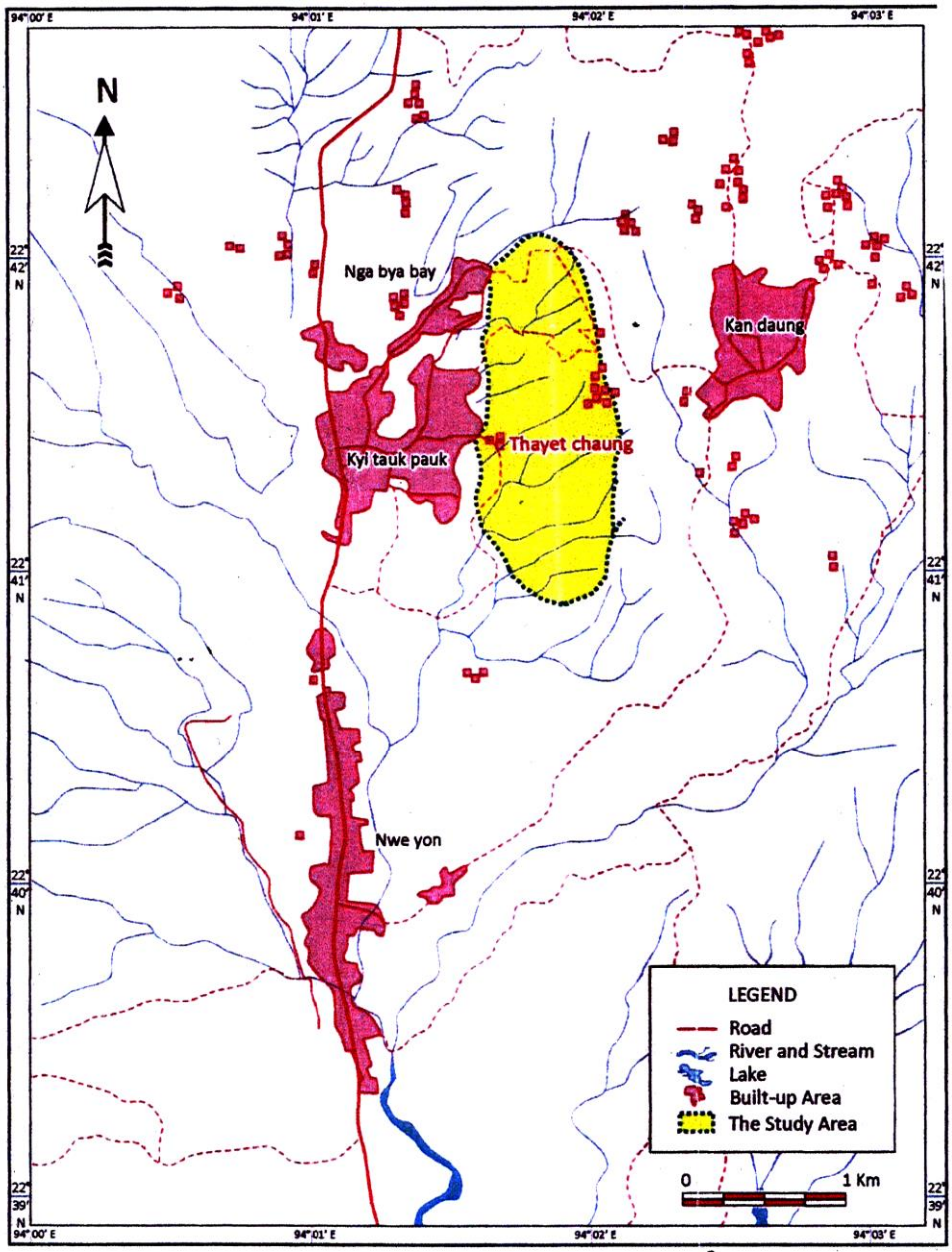

Figure (1) Location Map of the Study Area

Experimentals

Sample collection

Ten individual soil samples were collected from Tha yet chaung block gold mines and thoroughly combined them as gold mine Sample (1).

Ten individual soil samples were collected from Kyitauk pauk village gold processing sites and thoroughly combined them as processing Sample (2).

Ten individual soil samples were collected from paddy field of Nwe yon village near Tha yet chaung gold mines and thoroughly combined them as paddy field Sample (3).

Each soil sample was collected from 15cm depth of each site.

Gold Mine

Paddy Field

Gold Processing by Cyanization and Amalgamation

Figure (2) Sampling sites

Preparation of Multi-increment Soil Samples

Procedure

Ten individual soil increments collected was spaced out across each site as shown in following Figure (3). A multi-increment sample was made of ten individual soil samples or "increments" collected from each site were combined to make a multi-increment surface soil sample.

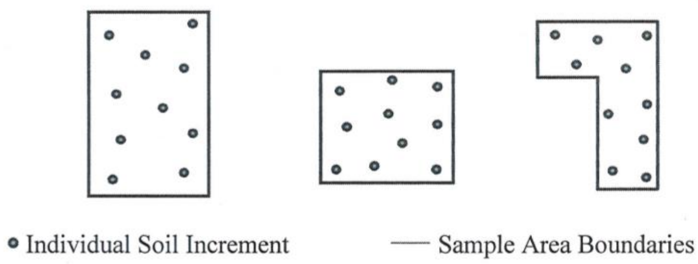

Figure (3) Three examples with approximate locations of ten soil sample increments spread across the specific sample areas

Then these soils were allowed to dry in air. The temperature was not exceeding 35ºC. Stone and pieces of macro-organic matters were picked out and the remainders were crushed and sieved. Large lumps were broken up by hand and then the soil was ground by milling with wooden roller. After grinding, the soil was screened through a 2mm (10 meshes) sieve. The greater than 2mm soil retained on the sieve was not be analyzed.

Materials and Methods

Determination of moisture content was carried out by electric oven. The pH of soil solution was measured by pH meter. The pH meter was calibrated with pH 4.0 and pH 10.0 buffer solution before measurement. Textural analysis was done by pipette method. Determination of available nitrogen was measured by alkaline permanganate method. Available phosphorus was determined by using Truog's method. To determine exchangeable calcium and magnesium, about 2.5 g of sample was weighed accurately and placed in a 500 cm^3 of 1 M NaCl solution. The bottle was shaken for 3 min and kept overnight and then filtered. 25 cm^3 of filtrate was added into conical flask and then 5 cm^3 of ammonium buffer solution (pH=10) was added. Eriochrome Black T was used as an indicator. It was titrated with 0.02 M EDTA solutions and violet colour was obtained in the end point(Jackson, 1962). Exchangeable Sodium, potassium and heavy metals examinations were performed by applying atomic absorption spectrophotometer (AAS).

Results and Discussions

Soil Sample (1) and Sample (2) showed greater alkalinity with pH(8.50) and (8.34) than the agricultural soil Sample (3) (7.91). Moisture %, EC and organic matter of sample(3) were highest values(5.92%,340.00mmhos/cm and 3.80) respectively.

Sample	pH	Moisture (%)	EC (mmhos/cm)	Organic matter
1	8.50	2.25	129.20	-
2	8.34	3.04	140.10	2.10
3	7.91	5.92	340.00	4.80

Table 1. Physicochemical properties of soils

Textural analysis indicated the texture of soil samples and they were presented in Table (2).

Among the tested exchangeable cation contents, Ca^{++} cation of soil sample (3) was increased to (29.73).

In heavy metal determinations, Cu,Pb,Zn,Cr and Fe concentrations of soil sample (1) and(2) were higher than sample (3).But Cd , As and Hg amounts of soil sample (3) was greater than sample (1) and (2).

Although mercury was used in amalgamation process, less amounts of mercury were detected in mining and processing sites. Mercury amalgamation was carried out in separate concrete tank and the resulting waste water from this process was not discarded in these sites and they used again and again by recycling technique. Then the gold producers disposed of their unwanted waste soil to the neighbouring villages. Therefore surface soils of agricultural land may be contained significant amount of mercury. Some heavy metals could be leached into the deep soil by weathering.

Table 2. Textural Analysis

Sample	%Composition				
	Sand (%)	Silt (%)	Clay (%)	Gravel	Texture
1	62.90	13.50	5.00	13.50	Sandy Loam
2	61.60	23.60	7.80	7.00	Loamy Sand
3	32.00	56.30	11.70	0.00	Silt Loam

Table 3. Available NPK

	N (ppm)	P (ppm)	K(ppm)
1.	30	10	8.80
2.	19	11	7.30
3.	56	25	84.00

Table 4. Exchangeable Cation Contents

Sample	meq/100 g of soil				
	Na^{+}	Ca^{++}	Mg^{++}	Al^{+++}	H^{+}
1.	1.32	17.01	4.94	N.D	N.D
2.	1.35	18.45	3.01	N.D	N.D
3.	1.51	29.73	2.29	N.D	N.D

Table 5. Heavy Metal Contents

Sample	Cd (ppm)	As (ppm)	Hg (ppm)	Cu (ppm)	Pb (ppm)	Zn (ppm)	Cr (ppm)	Ni (ppm)	Fe (ppm)	Ca (ppm)
1.	0.007	0.004	0.002	83.000	90	105	15	20	9600	65
2.	0.009	0.004	0.002	90.000	105	115	10	15	9250	85
3.	0.153	13.370	2.916	0.280	1.069	1.090	0.330	-	2.164	88.560
Euro-pean comm-unity	3.000	-	1.500	140	300	300	-	75	-	-

Conclusion

One alarming environmental problem is brought by artisanal gold mining activities. In Myanmar, goldmines of Tha yet chaung block, Sinkgu Township, Pyin Oo Lwin District, Mandalay Region are well known for its gold producing capacity. But it was followed by the thread of environmental issues. In this research, soil quality or soil health of these gold mines and its related area was determined and presented as a comparison. Among three tested samples, agricultural soil sample (3) informed as silt loam texture and mining and processing soil sample (1) and (2) indicated as sandy loam and loamy sand. Soil sample (3) responsed the highest electrical conductivity and major soil nutrients NPK. It gave low nitrogen, high phosphorus and low potassium values for agriculture. Among the tested soil samples, the highest NPK values were observed in agricultural soil. Cadmium, arsenic, mercury and calcium contents were also found larger than sample (1) and (2). Comparison with maximum metal concentration in soils permitted under European community regulations, mercury raised nearly twice of its limited concentration 1.5 mg Kg^{-1}. Except iron heavy metal, all tested heavy metal constituents were under the maximum permissible limited amounts.

Local people from gold mine and its surrounding area should take care the risk of heavy metal contaminants and have to apply protective gears while they have direct exposure with these surface soils. In addition, they should get more information about the knowledge of soil quality and manage their soils by advanced soil science technologies.

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